Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, D.C.

TSO-C205a

Effective
Date: 5/9/17

Technical Standard Order

Subject: Circuit Card Assembly Functional Class Delta Equipment Using The Satellite-Based Augmentation System For Navigation Applications.

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards (MPS) your circuit card assembly (CCA) functional class Delta sensor using the satellite-based augmentation system (SBAS) for navigation applications must first meet for approval and identification with the applicable TSO marking. TSO-C205a is intended as a means for end-use equipment manufacturers to streamline their TSO-C146e application for a class Delta-4 sensor by using the TSO'd Delta-4 CCA for partial certification credit. TSO-C205a is only intended for navigation applications; it is not intended for non-navigation applications.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

a. TSO-C205 will also remain effective until November 9, 2018. After this date, we will no longer accept applications for TSO-C205.

b. Functional class Delta-4 circuit card assemblies approved under a previous TSOA may still be manufactured under the provisions of its original approval.

3. REQUIREMENTS. New models of Delta CCA functional sensors identified and manufactured on or after the effective date of this TSO must meet the class Delta-4 MPS qualification and documentation requirements in RTCA, Inc. Document No. RTCA/DO-229E, "*Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment*," dated December 15, 2016, Sections 2.1.1, 2.1.5, and 2.3. Functional class Delta is defined in RTCA/DO-229E, Section 1.4 and Appendix 1 adds a new section 1.8.3.

> **Note:** Manufacturers have the option to use the RTCA/DO-229E change described in Appendix 2. This change is based on a past commonly granted deviation.

a. An alternate method for applicants with a TSO-205 TSOA is to apply for TSO-C205a using their existing approved design data plus additional substantiation data showing compliance with the changes in RTCA/DO-229E. The three areas where requirements changed are: 1) expanding the SBAS pseudorandom noise (PRN) codes (i.e., PRN range of 120 thru 158); 2) ensuring a graceful degradation to GPS-only operations; and, 3) prohibiting use of the broadcast Navigation Message Correction Table.

> **Note 1:** It is not necessary for applicants to re-submit previously approved deviations. Previously approved deviations, and any limitations, will apply to the TSO-C205a TSOA.

b. Functionality.

(1) This TSO's standards apply to equipment intended to provide localizer performance without vertical guidance (LP) and localizer performance with vertical guidance (LPV) deviation cues during the LP and LPV final approach segment. Pilots or autopilots will use the LP/LPV guidance cues to guide the aircraft.

(2) TSO-C205a equipment has a limitation requiring the end-use manufacturer to receive a TSO-C146e class Delta-4 TSOA. To receive a TSO-C146e class Delta-4 TSOA, the end-use equipment manufacturer is required to repeat selected performance tests in the end-use equipment and perform the environmental qualification tests in RTCA/DO-229E. These limitations must be documented in the installation/instruction manual (see paragraph **5.a**).

c. Failure Condition Classifications.

(1) Failure of the function defined in paragraph **3.b** resulting in misleading information for LP and LPV navigation data is a *Hazardous* failure condition, and

(2) Loss of the function defined in paragraph **3.b** for LP and LPV navigation data is a *Major* failure condition.

(3) Design the system to at least these failure condition classifications.

d. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in RTCA/DO-229E, Section 2.5.

e. Environmental Qualification. None. The Delta CCA functional sensor has a limitation requiring environmental qualification by the end-use equipment manufacturer at the end-use equipment level.

f. Software Qualification. If the article includes software, develop the software according to RTCA, Inc. document RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph **3.c** of this TSO. You may also develop the software according to RTCA, Inc. document RTCA/DO-178B, dated December 1, 1992 if you follow the guidance in AC 20-115C (or later revision), *Airborne Software Assurance*.

g. Electronic Hardware Qualification. If the article includes complex custom airborne electronic hardware, develop the component according to RTCA, Inc. Document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, to at least the design assurance level consistent with the failure condition classification defined in paragraph **3.c** of this TSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

> **Note:** Applicants should refer to AC 20-152 (latest revision) for guidance on implementing RTCA/DO-254.

h. Deviations. We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under the provision of 14 CFR § 21.618.

i. Barometric-aided Fault Detection and Exclusion (FDE). If the equipment uses barometric-aiding to enhance FDE availability, then the equipment must meet the requirements in RTCA/DO-229E, appendix G.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR § 45.15(b).

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

(1) Each component that is easily removable (without hand tools); and,

(2) Each subassembly of the article that you determined may be interchangeable.

c. If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

d. You may use electronic part marking to identify software or airborne electronic hardware components by embedding the identification within the hardware component itself (using software) rather than marking it on the equipment nameplate. If electronic marking is used, it must be readily accessible without the use of special tools or equipment.

5. APPLICATION DATA REQUIREMENTS. You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR § 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph **5.j**) through their civil aviation authority.

a. A Manual(s) containing the following:

(1) Operating instructions and article limitations sufficient to describe the equipment's operational capability.

(2) Describe in detail any deviations.

(3) Installation procedures and limitations sufficient to ensure that the Delta CCA functional sensor, when installed in the end-use equipment according to the installation or operational procedures, still meets this TSO's requirements for partial certification credit to the end-use equipment manufacturer. Limitations must identify any unique aspects of the installation. The following specific limitations must be documented in the installation instructions:

(a) "Delta CCA functional sensors are limited to navigation applications only."

(b) "Equipment manufacturers using the *<insert equipment model>* Delta CCA functional sensor for navigation end-use applications are required to receive a TSO-C146e class Delta-4 TSOA. The end-use equipment manufacturer is required to perform the testing described in TSO-C146e appendix 1 with the Delta CCA functional sensor installed in the end-use equipment to receive a TSO-C146e authorization."

(c) "End-use equipment manufacturers are required to complete full environmental qualification at the end-use equipment level."

(d) "This article meets the minimum performance and quality control standards required by a technical standard order (TSO). This article is only intended for installation in other avionics equipment."

(4) For each unique configuration of software and airborne electronic hardware, reference the following:

(a) Software part number including revision and design assurance level;

(b) Airborne electronic hardware part number including revision and design assurance level; and,

(c) Functional description.

(5) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the Delta CCA functional sensor equipment.

(6) List of replaceable components, such as an antenna, by part number, that makes up the Delta CCA functional sensor. Include vendor part number cross-references, when applicable.

(a) If the equipment can satisfy the requirements of RTCA/DO-229E only when used with a particular antenna, make the use of that antenna (by part number) a requirement on the installation. Include this requirement in the installation manual (IM) as a limitation.

(b) If the equipment can satisfy the requirements of RTCA/DO-229E with a standard antenna, include maximum tolerable currents and voltages into the antenna port. See TSO-C190, *Active Airborne Global Navigation Satellite System (GNSS) Antenna*, applicable to all equipment operational classes.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the Delta CCA functional sensor continues to meet the TSO approved design. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph **4** of this TSO.

f. Adequate specifics on the interface between the Delta CCA functional sensor and other systems to ensure proper functioning of the integrated system. This includes information on environmental characteristics necessary for reliable operation after integration such as maximum and minimum operating temperature of the Delta CCA. If

the equipment depends on any external inputs (like baro-aided FDE) to satisfy the requirements of RTCA/DO-229E, make those inputs a requirement in the installation. Include this requirement in the IM as a limitation.

g. If the software qualification limits eligibility of the equipment to certain aircraft types, identify the qualification level, and that the equipment is not eligible for all aircraft types. For example, AC 23-1309-1(), *Equipment, Systems, and Installations in Part 23 Airplanes*, states that RTCA/DO-178B Level C software may be associated with a *hazardous* failure condition for certain aircraft types. Identify other limitations applicable to the failure condition classification for example, that two installed units are necessary.

h. If the equipment has not been demonstrated as compatible with satellite communications (SatCom) record in the limitations section that the equipment should not be installed in SatCom equipped aircraft.

i. Identify functionality or performance contained in the article not evaluated under paragraph **3** of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph **3**.

(2) Installation procedures and limitations sufficient to ensure that the non-TSO function(s) meets the declared functions and performance specification(s) described in paragraph **5.i.(1)**.

(3) Instructions for continued performance applicable to the non-TSO function(s) described in paragraph **5.i.(1).**

(4) Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph **5.i.(1).**

(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).

(6) Test plans, analysis and results, as appropriate, to verify the function and performance of the non-TSO function(s) as described in paragraph **5.i.(1).**

(7) Alternatively, identify non-TSO functionality or performance contained in the article not evaluated under paragraph **3** and submit previously accepted data for the non-TSO function for acceptance in parallel with this TSO application.

j. The quality system description required by 14 CFR § 21.608, including functional test specifications. The quality system should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

k. Material and process specifications list.

l. List of all drawings and processes (including revision level) that define the article's design.

m. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3.d** of this TSO.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

b. Article calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. Material and process specifications.

f. If the article includes software, the appropriate documentation defined in RTCA/DO-178B or RTCA/DO-178C specified in paragraph **3.f** of this TSO, including all data supporting the applicable objectives in RTCA/DO-178B or RTCA/DO-178C Annex A, *Process Objectives and Outputs by Software Level*.

g. If the article includes complex custom airborne electronic hardware, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-l. For simple custom airborne electronic hardware, the following data: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

h. All the data necessary to evaluate the geo stationary (GEO) satellite bias as defined in RTCA/DO-229E, Section 2.1.4.1.5.

i. If the article contains non-TSO function(s), you must also make available items **6.a** through **6.g** as they pertain to the non-TSO function(s).

7. FURNISHED DATA REQUIREMENTS.

a. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or on-line access to the data in paragraphs **5.a, 5.b** and **5.f** through **5.h** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with the TSO, of the Delta CCA functional sensor.

b. If the article contains declared non-TSO function(s), include one copy of the data in paragraphs **5.i.(1)** through **5.i.(4).**

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA Inc., 1150 18th Street NW, Suite 910, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org .

b. Order copies of 14 CFR parts 21 and 45 from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.gpo.gov.

c. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at http://rgl.faa.gov/. You will also find the TSO Index of Articles at the same site.

Susan J. M. Cabler
Acting Manager, Design, Manufacturing, &
Airworthiness Division
Aircraft Certification Service

APPENDIX 1. ADDITIONs TO RTCA/DO-229E.

This appendix adds a new section 1.8.3 on cybersecurity and GPS spoofing mitigation to RTCA/DO-229E. The new section provides information for cybersecurity and spoofing mitigation to make RTCA/DO-229E consistent with the new RTCA MOPS template and RTCA/DO-253D.

1.8.3 Cybersecurity and Spoofing Mitigation.

This section contains information to address intentional interference to the GPS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed. Spoofing may be unintentional, such as effects from the signals of a GPS repeater, or may be intentional and even malicious. There are two classes of spoofing. Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of time of arrival or frequency of arrival or their rates of change. Data spoofing introduces incorrect digital data to the target receiver for its use in processing of signals and the calculation of PNT. Either class of spoofing can cause a range of effects, from incorrect outputs of PNT to receiver malfunction. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or installed GNSS re-radiators act like spoofers. Re-radiators replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognize and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document "Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure"[1] and IS-GPS-200 Revision H, IRN003 28 July 2016. RTCA/DO-326A and ED-202A along with RTCA/DO-355 and ED-204 may also be useful to assess vulnerabilities and identify mitigations.

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the development of the personal computer (PC) in the late 70's and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered vulnerable only through RF signals and OEM

[1] https://ics-cert.us-cert.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_(GPS)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf [Ed note: RTCA is investigating hosting this on their website]

and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft GNSS receivers may be field loadable by approved personnel, requiring physical access and physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update installed avionics software, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g., in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as "authorized services") which provide information to aircraft, such as ILS, VOR, GNSS, and DME, to name a few. However, the State typically does not provide oversight on "non-trusted"[2] connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit input of externally-supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerability through equipment design, or become vulnerable as a result of being connected to a common interface. Therefore, it is important that manufacturers consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in the MOPS, it is recommended that manufacturers look at a layered approach to aircraft information security risk mitigation that includes both technical (e.g., software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. From a physical perspective, a manufacturer could consider connectors that require special tools to remove to prevent passenger tampering; although, navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer is outsourcing software code development, is the contractor and its staff properly vetted?

Civil Aviation Authorities (CAAs) have a regulatory interest when an applicant's design makes use of a non-trusted connectivity where the installation can potentially introduce aircraft information security vulnerability. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerability could propagate to existing downstream systems. Additionally, aircraft manufacturers should consider establishing appropriate procedures for aircraft operators to maintain security protection of the equipment during the life of the equipment installation in the aircraft. Therefore, it is recommended that

[2] A "non-trusted" connectivity (sometimes referred to as third-party system) is any frequency or service where an Air Navigation Service Provider (ANSP) is not providing direct monitoring/protection.

manufacturers reference their equipment aircraft information security review and mitigation strategies so that the applicants can consider them, if necessary, in meeting the installation regulatory requirements.

Table 2-14 through Table 2-20.

The tables incorrectly reference and label RTCA/DO-160 sections 16.5.1.2 and 16.6.1.2 regarding “2.1.1.7 Acquisition Time” and “2.1.1.9 Reacquisition Time.” Change the table references as follows:

The MOPS Initial Acquisition Time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating condition (DO-160E section 16.5.2 and 16.6.2) and the Satellite Reacquisition Time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating condition (DO-160E section 16.5.1 and 16.6.1).

APPENDIX 2. OPTIONAL CHANGES TO RTCA/DO-229E ADDRESSING COMMON DEVIATION REQUESTS.

This appendix describes a change to RTCA/DO-229E based on a deviation commonly granted in the past and manufacturers have the option to use the change. Implementing this change to RTCA/DO-229E should reduce the need for a deviation request.

2.3 Class Delta-4 Requirements for Approach Operations.

Add the following note after the last paragraph in section 2.3:

Note: It is acceptable for manufacturers to not implement LP approach capability in their equipment provided the equipment has an appropriate limitation and LP approaches are not available for selection by the pilot.